Solid Oxide Fuel Cell Hybrid System for Distributed Power Generation

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Objectives

- Analyze and evaluate planar SOFC/gas turbine system concepts.
- Resolve technical barriers in pressurized planar solid oxide fuel cell (SOFC) operation and high-temperature heat exchangers.
- Perform an economic evaluation of the proposed system.
- Develop a detailed conceptual system design.
- Demonstrate coupled planar SOFC and turbo-machinery operation.

Milestones

- Perform preliminary system concept evaluations.
- Complete heat exchanger feasibility testing.
- Demonstrate pressurized planar SOFC operation.
- Evaluate SOFC stack scale-up.
- Complete economic evaluation.
- Create detailed system design and component specifications.
- Document cost estimates for complete system.
- Demonstrated coupled operation of a planar SOFC and turbo-machinery.

Approach

The program aims to demonstrate a proof-of-concept planar SOFC/gas turbine hybrid system for distributed power generation applications. The hybrid system concept is based on integration of planar SOFC and gas turbine power technologies. The SOFC operates at 800°C with fuel from a steam reformer. The exhaust air and fuel streams from the SOFC are combusted and provide heat to the steam reformer before entering the gas turbine. The SOFC is based on thin-film electrolyte technology fabricated with the tape calendering method and thin-foil metallic interconnect leading to a low-cost, high-performance, compact planar SOFC. The gas turbine is based on commercial products.

The hybrid system based on this approach has the following attractive features:
High efficiency: The proposed hybrid system has a potential for efficiency greater than 65 percent.
Low cost: The combination of planar SOFC and commercial gas turbine leads to a low-cost distributed generation solution.
Low emission: The highly efficient hybrid system will result in low greenhouse gas emissions.
Low noise: The hybrid is a low-noise system that gives siting flexibility for distributed power generation.

The work in this program focuses on defining and optimizing a suitable system concept, conducting experiments to resolve identified technical barriers, performing economic and cost analysis, and testing a small hybrid system to demonstrate concept feasibility.

Results

Progress in this program can be summarized in several areas:

- Preliminary design concepts for both the feasibility demonstration system and the conceptual system have been analyzed and evaluated.
- A preliminary design for high temperature heat exchangers for hybrid system applications has been developed.

Table 1.

		Improved Cell		"Baseline" Cell		
Fuel Util., %	Pressure, atm	Cell V, V	PD, W/cm²	Cell V, V	PD, W/cm²	PD increase, %
75%	1	0.687	0.235	unstable		
75%	2	0.688	0.394	0.636	0.183	115%
75%	3	0.701	0.402	0.685	0.197	104%

(PD = power density)

- Pressurized operation of planar SOFC stacks has been demonstrated. Performance data for a stack module is presented in Figure 1. This figure shows the polarization curves collected at 1, 1.5, 2, 2.5, and 3 atm, also included are the corresponding power density curves.
- Cell performance at high fuel utilization has been doubled for pressurized planar SOFCs operated at 800°C. The results for an improved cell at 800°C with 64% H_2 (balance N_2) are compared to a baseline performance obtained at 1, 2, and 3 atm in table 1 above.

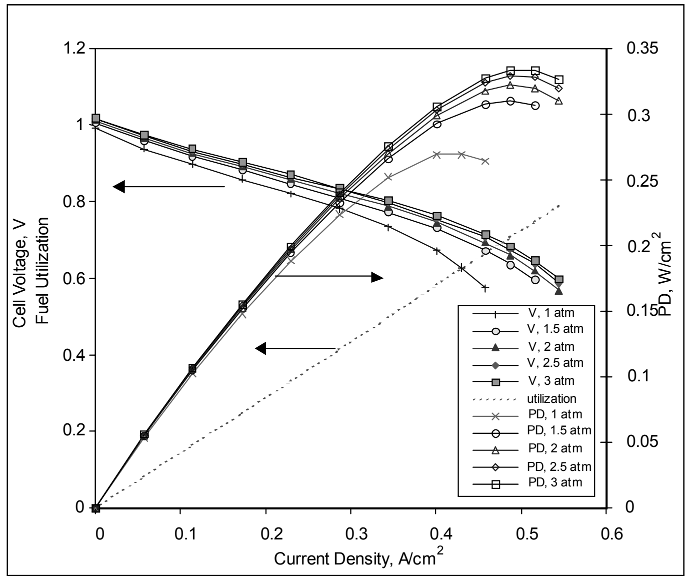

Figure 1. Polarization and power density curves at 800°C for planar SOFC at various pressures with fuel containing 64% hydrogen balance nitrogen.

Conclusion

The Solid Oxide Fuel Cell Hybrid System for Distributed Power Generation project was awarded in FY 2001. Significant progress has been achieved in defining hybrid system concepts, evaluating their performance characteristics, and demonstrating pressurized planar SOFC operation. Cell performance at high fuel utilizations under pressure has been doubled. Future work will continue in the various technical areas of the program. Planar SOFC/gas turbine hybrid systems have the potential for high efficiency along with other attractive features such as low cost, small size, and low emission.